# *The Life and Work of Meghnad Saha*

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# Foreword

This is the third book in the Supplementary Readers in Science Series for students of Higher Secondary classes.

Professor Meghnad Saha was one of the greatest scientists and teachers this country had produced. He was born in a small village in East Bengal, and was educated in Dacca and Calcutta. He first became a Professor at Calcutta University and then went over to Allahabad University. From Allahabad, he returned to Calcutta where he established the Institute of Nuclear Physics which has now been named after him. Both at Calcutta and Allahabad Professor Saha gathered round him a group of research workers who are today some of the eminent men of science in the country.

Professor Saha always identified himself with the nationalist forces of the country. He refused to accept any foreign degree or honour except the honour conferred on him by the Royal Society of England which elected him a Fellow at the early age of 33.

This short biography of Professor Saha is being presented to students in the hope that they will be inspired by his example.

NEW DELHI
*15 April 1968*

R. N. RAI

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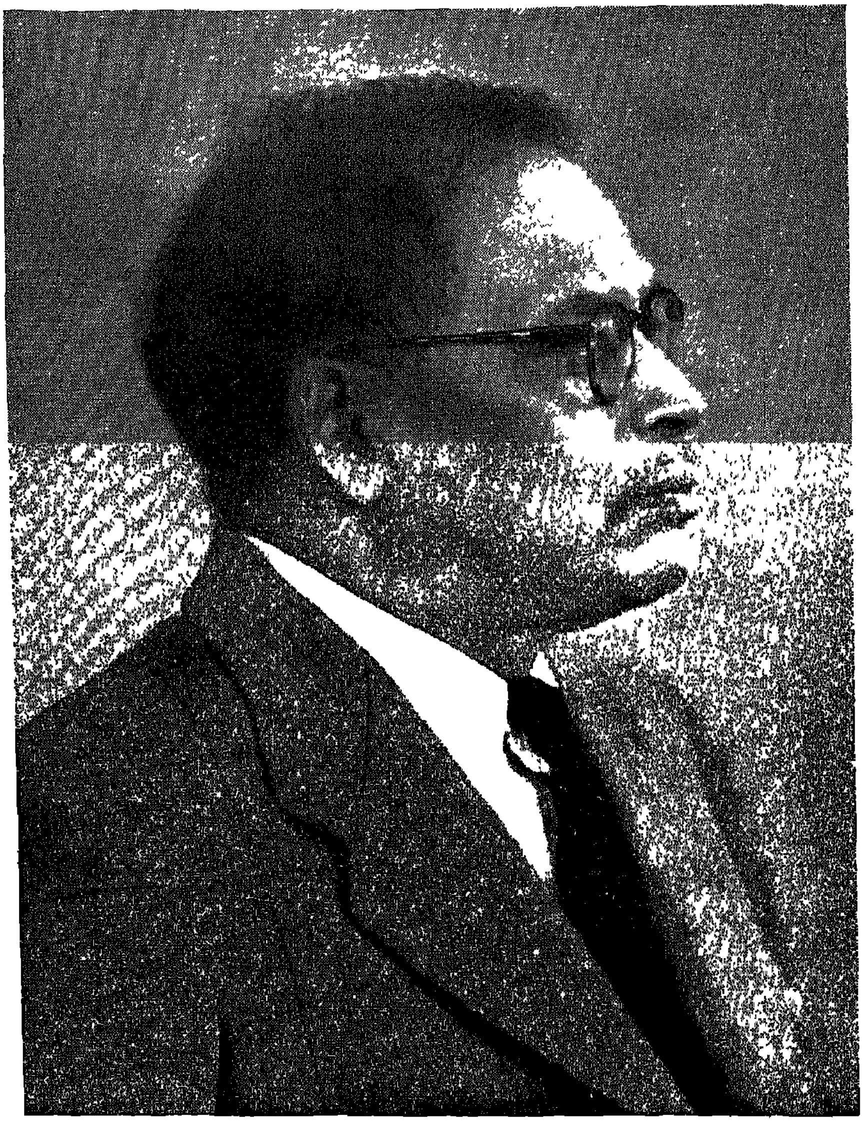


MEGHNAD SAHA

6 OCTOBER 1893 — 16 FEBRUARY 1956

# *Who was Meghnad Saha ?*

February 16 of the year 1956 was a day of rejoicing and festivity. It was early spring, *Vasant Panchami* and *Saraswati Puja* were being celebrated. *Saraswati* is the goddess of learning, music and fine arts. Suddenly the radio announced the death of Meghnad Saha. The music and rejoicing came to an abrupt end. The people of India and other countries were plunged into grief.

Who was Meghnad Saha ? Why did people all over the world mourn his death ?

Professor Meghnad Saha was a great scientist and a noble son of the country. He was not only a renowned scientist of India, but recognized as a great scientist all over the world.

He used to worship *Saraswati* the goddess of learning. But his method of worship was a little different. There is a very interesting story about it.

Two years before Dr. Meghnad Saha died, the children of his locality in Calcutta approached him to collect a subscription for the *Saraswati Puja.* Dr. Saha asked, 'How are you going to perform the *Puja ?*'

The children were amused at this question, wondering if such a learned man did not know how the *Saraswati Puja*

was performed. They said, 'Sir, we have made the image of the goddess and the priest will perform the *Puja*. We have set up microphones for the music performance, and will be staging plays in the evening. This is the way we celebrate *Saraswati Puja*'.

Dr. Saha said, 'Come with me upstairs; I shall show you how I pay respect to the goddess of learning.'

The children followed him. As they entered Dr. Saha's study room, they found big shelves full of books. There were thousands of books, they were in English, French, German and Sanskrit. Most of the books were on science, but some were on history, economics, philosophy, religion and other subjects. His table too was full of books; writing paper, pencil and pen were also on the table.

The children then realized that Dr. Saha had been busy reading and writing.

Dr. Saha told the children, 'If you study hard, you pay the greatest respect to the goddess of learning. This is the best way to perform Her Puja'.

# 2

## *School-days*

Meghnad Saha was born on October 6, 1893, in the village of Sheoratali in the district of Dacca. He was the fifth child of his parents.

Meghnad's father, Jagannath Saha, ran a grocer's store in the village. The family depended on the income from the shop. The income was small, but his mother Bhubaneswari Debi managed the household so efficiently that no one felt deprived of anything.

There was no high school in the village of Sheoratali. So, Meghnad studied in the village primary school. His father decided to train Meghnad in running his shop. He had no desire to give his son an English education at the high school in Dacca, thirty miles away. Meghnad was admitted to the local primary school. When not busy in school he worked with his father at the shop. Young Meghnad did not enjoy the work in the shop. He was very good in his studies at the school. When he finished his primary education, his teachers, rather impressed with his intelligence and industry, were keen that he should go on to a high school. They talked to Meghnad's father about it. But Jagannath found it difficult to arrange for his high school

education. Jaynath, the eldest brother, was thirteen years older than Meghnad. Jaynath had been educated in a high school, and was anxious that his younger brother should continue his studies in a good school.

There was a middle school, in the village Simulia, seven miles from Sheoratali. Jaynath thought that the middle school would be good enough for Meghnad for the time being. But young Meghnad could not possibly walk fourteen miles every day. So, Jaynath went to Simulia and met Shri Ananta Kumar Das, a doctor in Simulia. Doctor Das agreed to allow Meghnad to stay at his house so that he could go to school conveniently. Meghnad Saha gratefully remembered Doctor Das throughout his life for this kindness.

Meghnad stood first in the district of Dacca in the middle school examination. This won him a scholarship, and made it easy for him to continue his studies. He entered the Dacca Collegiate School in 1905 and did so well in his studies that he was exempted from the payment of school fees, and was also given a scholarship.

Every thing seemed favourable for Meghnad. But soon difficulties came in his way. The then British government in India partitioned Bengal into two parts. People protested against the partition, and the *Swadesi* movement started. Sir Ramfield Fuller was the Governor of Bengal at that time. He went round to visit schools and colleges. The students observed *hartal* and did not attend their classes as a protest against the partition of the province. Young Meghnad also took part in the *hartal*. As a result, many students, including Meghnad, were expelled from schools and colleges. His scholarship was also stopped.

Meghnad found himself in a difficult situation. No government school would admit him. His scholarship had been withdrawn.

Every dark cloud has a silver lining. The Kishorilal Jubilee School in Dacca admitted him, and even gave him a scholarship. His brother Jaynath also gave Meghnad some monetary help. Thus Meghnad was able to resume his school studies.

After a few months, Meghnad entered the Bible class in the Dacca Baptist Mission. Was he going to accept Christianity ? Not really. Meghnad was fond of studying history. Study of religion gives one a better understanding of the ancient history and civilization of a country, including the history of science, especially, of astronomy. Astronomy is the oldest science in any country, and the religious scriptures give us some information about this branch of science in olden days. Meghnad studied Hinduism, Christianity, Islam, Buddhism and Jainism.

In the Baptist Mission, Meghnad studied the Bible very diligently. The mission held an all-Bengal Bible examination. Meghnad took the examination along with many college students and to every one's surprise it was school boy Meghnad who stood first. He received a copy of a beautifully bound Bible and one hundred rupees, as a prize.

In 1909, Meghnad stood first in the Entrance examination in the whole of East Bengal. He got the highest (aggregate) marks in English, Bengali and Sanskrit and also stood first in mathematics.

Meghnad was always devoted to his studies; keen to learn his subjects well. He had great respect for his teachers. Later, when he became a teacher, he received the same respect from his students.

# 3

## College

After passing the Entrance examination, Meghnad entered the Dacca College. While studying science for the Intermediate course, he also began learning the German language. This was for two reasons. He had already made up his mind to become a scientist and knew that a good scientist should learn German. Germans were far advanced in science, and many research papers were published in that language. The other reason was to take German language as his fourth subject. His three main subjects in the Intermediate Science course were physics, chemistry and mathematics. German language, he felt, as his fourth subject, would yield him a high aggregate. He studied German under Doctor Nagendra Nath Sen who had just returned from Germany with a Ph.D. degree in chemistry. Meghnad was fortunate to study under many of the great teachers of those days. Professor K.P. Basu, whose book on algebra is well known, was one of Meghnad's teachers. The teachers were very fond of Meghnad. He stood first in mathematics and chemistry in his Intermediate examination, but obtained third position in the aggregate. Principal Archibald foresaw that Meghnad had in him the makings of a great scientist. He guided Meghnad through correspondence even long after Meghnad had left the college.

After his stay in Dacca, Meghnad came to Calcutta for higher studies. In 1911 he joined the Calcutta Presidency College and took up mathematics for the B.Sc. Honours course. Many brilliant students were studying at that time in the Presidency College, and later many of them became leaders of science in the country. Satyendra Nath Bose, one of the great scientists today, was Meghnad's class-mate. Nikhil Ranjan Sen, J.C. Ghose and J.N. Mukerjee were his other class-mates who later became well-known professors at the different universities. P.C. Mahalanobis and N.R. Dhar were senior to Meghnad Saha. Sarat Bose was his contemporary, and Subhas (Netaji) was three years junior to him.

These young people had the rare fortune of coming in close contact with master minds in the field of science in the country. The great men who taught and inspired these young students were none other than Jagadish Chandra Bose who taught them physics, Acharya Praphulla Chandra Ray who taught them Chemistry, and D.N. Mallik who taught them mathematics. They were not only good teachers, they were also great nationalists inspiring in their students a striving for great ideals.

Meghnad secured first class in his Bachelor and Master of Science examinations, standing second in the order of merit. The first position in both the examinations was held by Satyen Bose. Later, these two brilliant mathematicians became world renowned physicists. This is not surprising, for, mathematics is the fundamental basis for science.

Having completed his university education, Meghnad's problem was to secure a good job. He was poor, and needed a job without any delay. Intelligent and bright

students used to appear for the competitive examinations, like the Indian Civil Service, Finance or Police Service. Meghnad thought of trying for the Finance Service examination, but the British Government of India did not permit him to do so. Although Meghnad had the spirit of nationalism in him he did not take any active part in politics. But some of his friends and acquaintances were active nationalists and even revolutionaries. This was enough plea for the British Government to debar him from the service examinations.

Among Meghnad's friends were Subhas Chandra Bose, Tiger Jatin, and the gymnast Pulin Das. Jatindra Nath Mukerjee earned the nick-name Tiger Jatin (*Bagha* Jatin) as he had killed a tiger in a fight, with just a dagger. It was not merely his physical strength, but his mental strength that won him victory in his encounter with the tiger. Jatin was not satisfied with fighting the tiger. He was determined to fight the British lion as well. He would often visit the students' hostel where Meghnad was staying. This was during the years 1913 to 1915. The First World War between the British and the Germans was on. Jatin thought this to be an opportune moment to launch a revolutionary movement against the British in India. He arranged for weapons to arrive at Sunderbans from Germany. But he was killed in an encounter with the police near Baleshwar.

Pulin Das had a gymnasium, where he taught physical culture, sword-fighting and gymnastics. Besides, he indoctrinated the young men and women in nationalism. The police and the British Government spies kept a close watch on the gymnasium

Meghnad knew these spirited nationalists intimately, but did not lend himself to their activities. He could not afford it. Poverty pursued him. He had to maintain himself, and had to support his younger brothers, and arrange for their education. Besides, he had a great interest in science. He was determined to pursue scientific research and not get distracted by political activities.

His only source of income at this time was the private tuition to a few students. He gave lessons to two or three students in different parts of the city of Calcutta, some in Shambazar, others in the Bhowanipur area. This meant going backwards and forwards a considerable distance everyday. Meghnad could not afford even the tram fares to reach the houses of the students whom he taught. He would either walk the distance or ride the bicycle.

# *Teaching and Research*

Meghnad took his Master of Science degree in 1915 and spent a year after that in extreme poverty. The next year, Professor Asutosh Mukherjee, the then Vice-Chancellor of the Calcutta University, offered Meghnad a lecturer's post in the Mathematics Department of the University.

Unfortunately, Meghnad did not get on well with the head of the department, Professor Ganesh Prasad and was transferred to the Physics Department.

Thus Meghnad moved from mathematics to physics. Meghnad had now to teach post-graduate classes in physics. He had of course studied physics for his Bachelor's, but only as a pass subject. He had taken up mathematics for his honours course, and his post-graduate degree was also in mathematics. It was therefore not an easy task for him to teach physics at the post-graduate level. But he knew that as mathematics is the basis of higher physics, it would not be impossible to catch up with it.

Meghnad worked very hard, and soon proved himself to be a good teacher of physics. He studied hard not only to teach but also to carry on research in physics. His knowledge of German was a great advantage. He studied Einstein's Theory of Relativity which was published in

German and of which there was no English translation at that time. Einstein's theory is highly mathematical, but for Meghnad whose strong point was mathematics, it was not difficult to master the Theory of Relativity. Later Meghnad Saha and his colleague Satyen Bose translated this Theory into English, and it was published by the Calcutta University.

What is the Theory of Relativity ? It is a very difficult concept to explain. One has to have the knowledge of advanced mathematics and physics to understand it. But let me tell you a story.

In 1919, news came that Einstein's Theory of Relativity had been proved correct. What he had predicted by his mathematical calculations was found to be correct : 'Light from the star had bent while passing by the sun'.

How did this happen ? What did it mean ? It was a puzzle to everyone. The news came by a cable from England to the Calcutta office of a newspaper, The Statesman. But unless the significance of the news was grasped, it could not be published. So the newspaper men looked for someone who could explain the matter. Luckily they met Meghnad Saha at the Presidency College. He explained the meaning of 'the bending of light', and his news article on the subject was published the next day.

According to the Theory of Relativity, light also has mass, like a piece of any matter or a minute particle of stone. If this is so, then light should be attracted by gravity. If a piece of stone is thrown upwards, it does not keep going upwards, but it bends downwards and falls on the ground due to the pull of the earth's gravity. Einstein put forth that light also has some mass and is attracted by gravity.

In that case, if you turn on an electric torchlight and point it horizontally, the light should not strike the wall of the building across the street, but it should bend down and strike the ground. But we do not see it happen that way. Is Einstein wrong then ? No, let me explain. When we throw a stone it bends and falls down within a short distance, because the speed of the stone is small. But if we shoot a bullet from a gun it goes a much longer distance before striking the ground, because its speed is very great. The speed of light, as you know, is three hundred thousand kilometres per second (1,86,000 miles per second).

The earth's gravitational pull is not strong enough to show the bending of light rays in an easy manner. The bending is, in fact, too small to detect. Einstein said that earth is not massive enough to exert sufficient pull to bend light rays noticeably. If the earth were bigger and heavier it could show its effect on light, for, heavier bodies have stronger gravitational attraction. Einstein said that the sun is 330,000 times heavier than the earth, and the sun's gravitational pull on light from a distant star should

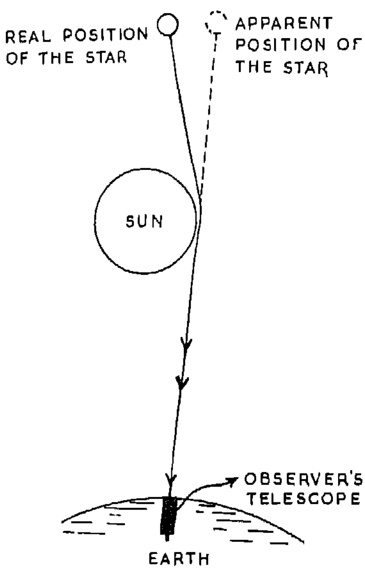



*Fig. 1 The diagram shows the deviation of light from a star when the light passes close to sun. The sizes and distances of the sun, earth and star are not to proportion.*

bend it perceptibly. The sun is nearer to us than the stars. If a distant star is peeping from behind the sun we can see the star just by the side of the sun. This means that the star light passes close to the sun before it reaches us. Einstein predicted, as a result of his Theory of Relativity, that the star light will bend due to the sun's pull and we would see the star as if shifted from its real position in the sky (Figure 1). But the difficulty is that we cannot see a star along by the side of the dazzling sun. Einstein suggested that we can observe the 'star-shift' only when the dazzle of the sun is covered at the time of a total solar eclipse. The prediction made by Einstein was verified during the total solar eclipse on May 29, 1919.

Einstein propounded that 'light has mass, so that when light strikes a surface it will give it a push or pressure'. Earlier, James Clerk Maxwell had the same idea about the pressure of light. Both Maxwell and Einstein calculated the pressure of light mathematically. But no one was able to demonstrate the pressure practically. The pressure of light is so feeble that it cannot even move a feather on the table. Between 1900 and 1902 many American and Russian scientists tried experiments to measure the pressure of light, but no one was successful.

Meghnad Saha was the first scientist to build a very delicate instrument and demonstrate practically that light does give a push or pressure when it falls on a delicate object. Saha measured that pressure which proved the Theory of Light-pressure. For this work he was awarded the degree of Doctor of Science (D.Sc.) by the University of Calcutta in 1918. He was then 25 years old.

## *What is the Sun made of ?*

There are some scientists who watch the movement of the planets, find out the laws of their motion, predict their

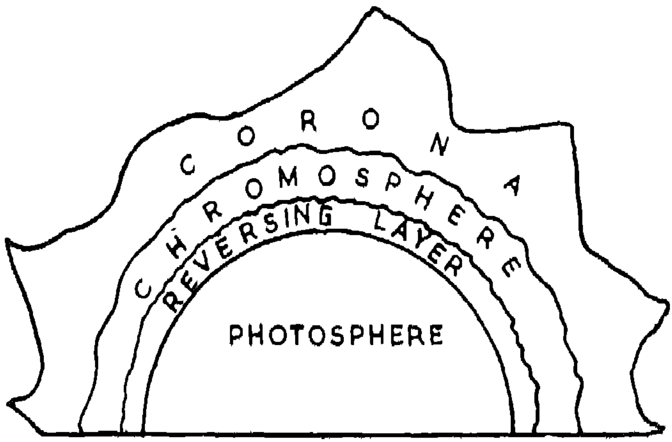



*Fig. 2 Schematic representation of the sun and its atmosphere*

future positions by calculation, and locate the stars and nebulae. These scientists are known as astronomers. Other scientists want to find out what the sun and the stars are made of; why they are so hot and bright; when and how they were born ? These scientists are called astrophysicists.

Our sun is nothing but a star in the sky. The stars are much farther away from us than the sun. So the stars look

smaller, although some of the stars are much bigger than the sun.

How can we know about the stars and the sun? We can know about them through the light which they give out. When the light from the sun or the stars is passed through a triangular glass prism, the white light appears coloured.

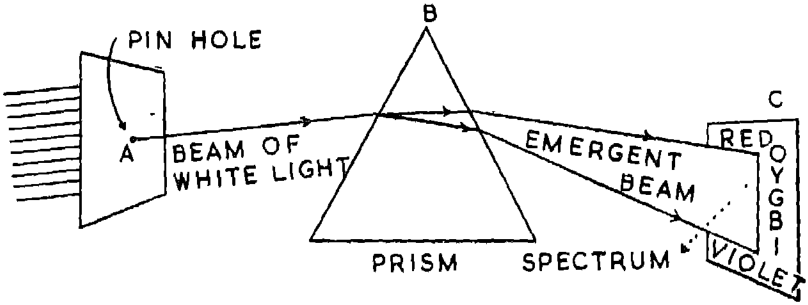



*Fig. 3 Radiation is the astronomer's source of information. Prism separates light according to wave length. This is the principle of a spectroscope*

White light is a mixture of coloured lights. A prism can thus split white light into its coloured light components. The band of colours so obtained is called a spectrum. The instrument by which the colour of light is measured is called a spectrometer. Seen through a spectrometer, the colours are found arranged in this way : at one end is violet then indigo, blue, green, yellow, orange and finally red stands at the other end of the spectrum (as shown on the screen C in Figure 3). Some of the colours in the spectrum stand as coloured lines. These are known as spectral lines.

Scientists have burnt hydrogen, oxygen, calcium, iron and all other substances and produced their lights. They

have analyzed these lights and photographed their spectra. So they know the spectral colour or spectral lines of each substance. Now when they analyze the lights from the stars and the sun, they can find out the nature of the substances that are burning there, by comparing the new spectral lines with the known ones. See Figure 4.

This sounds simple. But some of the spectral colours of the sun and stars could not be understood by scientists. These colours did not match with the colours of known substances when burning.

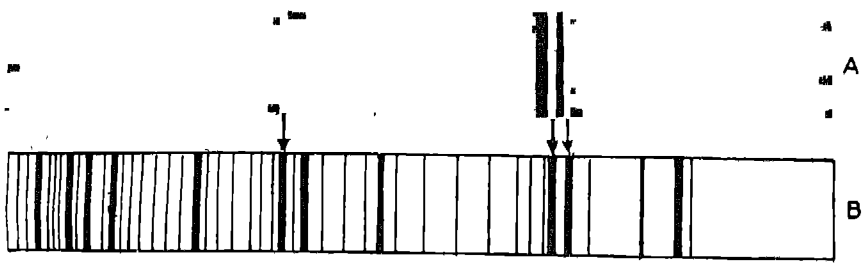



*Fig. 4 'B' shows the dark lines of part of the solar emission spectrum. 'A' shows the absorption spectrum of an element. Presence of the element in the sun is inferred by comparing the two spectra.*

Dr. Meghnad Saha wanted to solve the mystery. He began to study all about the spectra of the stars and the sun. To prepare himself for this research, he carefully studied all the Royal Astronomical Journals published in the past 25 years. Then he started thinking on the problem and made mathematical calculations. He found the solution, of course not as easily as I have said, but after many, many long hours of study and calculations. This is what he found.

The gases in the burning sun are not like ordinary gases or vapours which are electrically neutral. Ordinarily atoms are composed of equal amount of positive and negative electrical particles. So, an atom is not normally electrified. The atoms of the gases in the sun are under extraordinary heat and pressure which make the atoms break up. The atoms, then no longer remain electrically balanced or neutral. These become electrified or 'ionized'. This is known as the process of thermal ionization. Saha pointed out a method to recognize the presence of an element in stars. According to this method one would know the state of thermal ionization in which the element exists there. By calculations he could tell the degree of ionization expected to be prevailing at the different stars. Thus he could tell what kind of spectral light one could expect. The predictions made by him on the basis of his Thermal Ionization Theory were found to be correct. Saha's Thermal Ionization Theory was published in the Philosophical Magazine of London in 1920. He was then 27 years old.

# 6

## *Trip to Europe*

In the year 1919 Dr. Meghnad Saha received the Premchand Roychand Scholarship and the Gurprasanna Travelling Fellowship of the Calcutta University. This enabled him to proceed to Europe towards the end of that year. He was eager to meet some of the notable scientists and continue his line of research which he had started in India. A number of Indian scientists were on board the ship in which Meghnad travelled including the great teacher, Acharya P.C. Ray.

On arriving in London, Dr. Saha realized that his funds would not permit him to stay at Oxford or Cambridge University, being too expensive. He went to see his friend, Snehamoy Datta who was then studying for his Doctor of Science degree at the Imperial College of Science, London. On his advice, Dr. Saha saw Professor Fowler at the Imperial College.

The advice proved fruitful. Professor Fowler was a renowned scientist in spectroscopy. Dr. Saha also wanted to do research in the same line. Professor Fowler was very pleased with Dr. Saha's interest in research, and made him his research associate. Fowler had already written vastly on the subject, and together they started revising the written material.

As Saha worked with Professor Fowler, his knowledge of spectroscopy became deeper. His own theory—Saha's Thermal Ionization Theory—was also estabished on a sound footing.

But Meghnad was not fully satisfied. His theory enabled him to explain the spectra of the sun and stars. But he wanted to prove the effects of temperature and pressure in the laboratory. He wanted to heat different gases and metal vapours under intense heat and under different pressures almost similar to those obtaining in the sun. If he could get such an apparatus, he could show directly that his theory was also applicable to spectra of light observed in the laboratory. But there was no such apparatus in the Imperial College. One day Meghnad expressed his desire to Professor Fowler. Since there was no such apparatus in the laboratory, Professor Fowler asked Meghnad to enquire at the Cavendish Laboratory, Cambridge.

Dr. Saha went to see Sir J.J. Thomson at Cambridge. They had a discussion for an hour. Professor Thomson, an outstanding scientist, was very much impressed with the research ideas of the young Indian scientist, but there was no such apparatus at the Cavendish Laboratory which Saha could use for trying out his theory in the laboratory.

Meghnad gave Professor Fowler a detailed account of the discussion he had had with Sir Thomson. Professor Fowler observed that Meghnad was sorely disappointed as he had not been able to obtain a suitable apparatus for his thermal ionization experiment anywhere in England. But the young man's sincerity and devotion to his subject pleased him and he wanted to help him as much as he could. He therefore

asked Saha to write to Professor Nernst in Germany who he thought might be able to provide him with the apparatus. Saha wrote to Professor Nernst.

Meanwhile McLennan started experiments with Saha's thermal ionization theory. McLennan selected mercury vapour for his experiment, but could not get the kind of spectrum that Dr. Saha had predicted. McLennan concluded that Saha's theory must be wrong. Dr. Saha came to know about McLennan's experiment and told him that it would not be easy to get the effect indicated in his theory as mercury was difficult to ionize in the laboratory. Very intense heat was required for the purpose. Such a high temperature could not be produced in the laboratory. On the other hand alkali metals like sodium and potassium could be ionized more easily by heat produced in the laboratory. Some other elements like rubidium and caesium could be ionized very easily by ordinary heat. Under the intense heat of the sun these substances became so highly ionized that they failed to show their characteristic light. Saha further said that such light could possibly be obtained from the darker sun-spots, where the heat is not so intense.

After a month, Professor Henry Norris Russel from America wrote to Dr. Saha that his prediction was correct : the sun-spots did show such light. Russel had found it through the 100-inch telescope which was the largest available at that time.

By then, Dr. Saha had gone to Germany to Professor Nernst's laboratory. This was after the First World War. The Germans had been defeated by the English. Naturally, the Germans did not like the British or their associates. At

that time India was under the British rule. Therefore, when Saha went to Germany, it was doubtful if an Indian would be taken into the laboratory. But Professor Nernst was greatly pleased with Dr. Saha, and gave him all the facilities of his laboratory. Saha's knowledge of the German language helped him immensely in his work. Other German students and professors also encouraged Dr. Saha to experiment on his theory. His experiment and research progressed extremely well under these favourable and encouraging conditions.

## *Hurried Return*

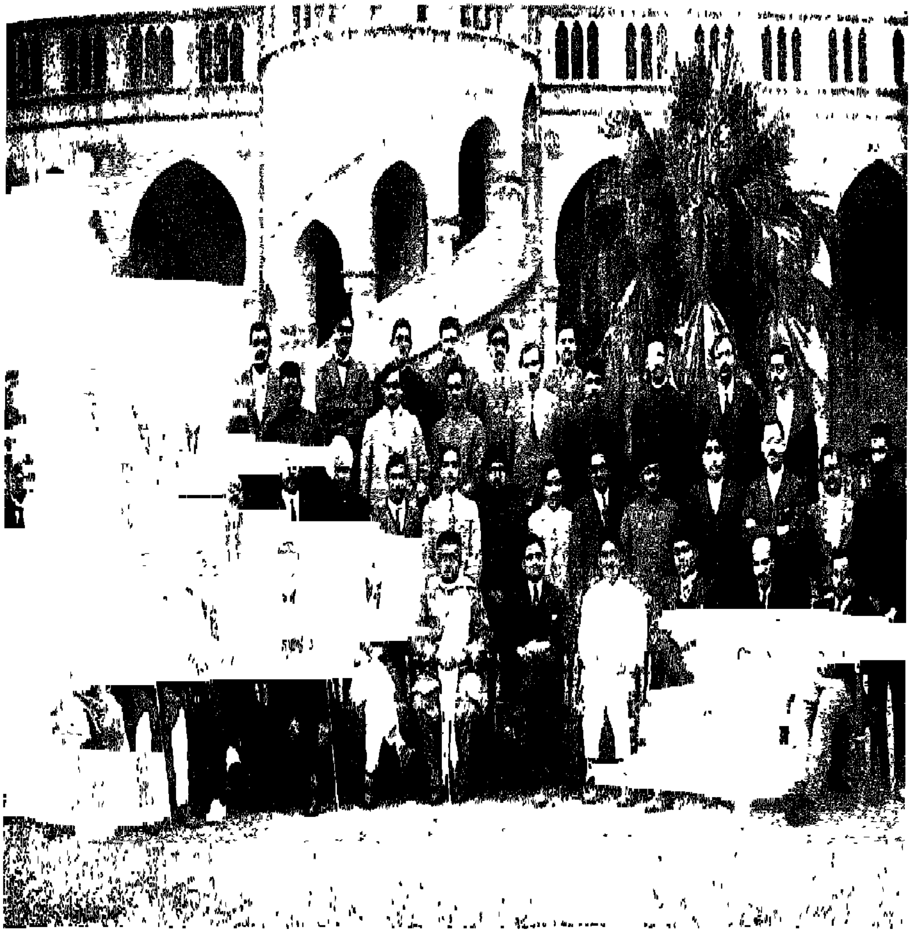
Dr. Saha returned to India hurriedly from Germany in 1921, as Sir Asutosh Mukerjee had sent him a cable offering a professorship at the Calcutta University. Shri Guruprasad Singh of Khaira Estate of Punjab had donated money to the University. A professor's post had been created with this endowment. Sir Asutosh requested Dr. Saha to take up the Khaira Professorship to teach physics and organize research at the Calcutta University.

Sir Asutosh was a keen educational reformer. He wanted to strengthen the University and build it up as a fine research centre, although, the British Government in India did not encourage this effort. The funds to appoint a professor came from the Khaira Estate, Meghnad Saha was appointed to this post. But more money was required to buy apparatus, books, and to appoint research assistants. Sir Asutosh asked the Government of Bengal for help, but he did not get any.

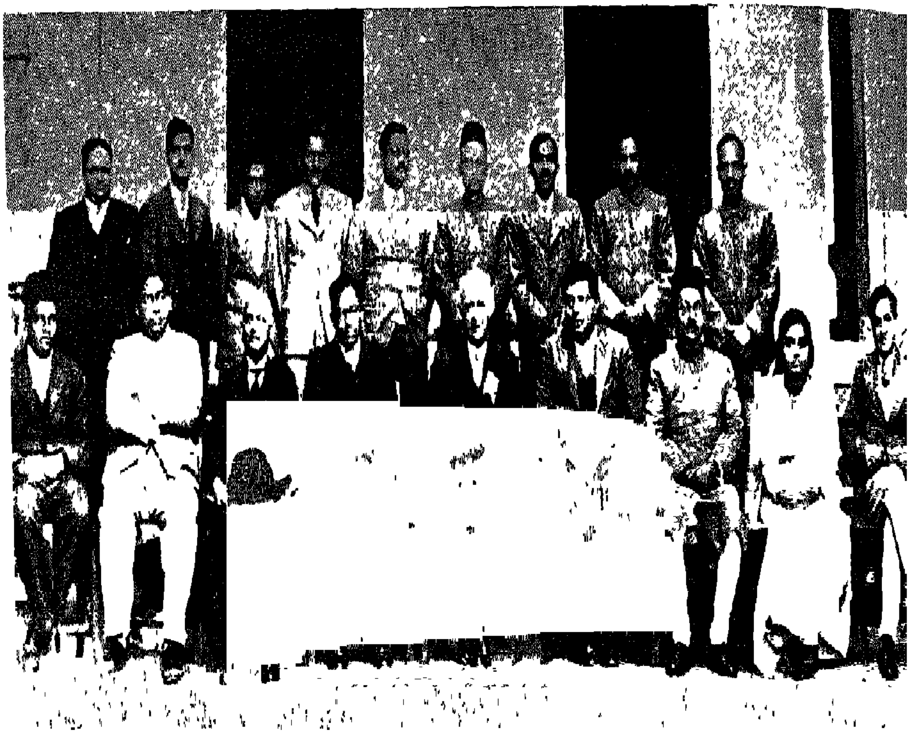
The lack of funds proved a serious handicap to Professor Saha in carrying out his research. All he wanted was a university where he could carry on his research. Aligarh and Banaras Universities were eager to have Saha. Dr Santi Swarup Bhatnagar was then the professor of chemistry at

the Banaras University and wanted his friend, Dr. Saha, to join the University. But facilities for research in Physics were equally inadequate in these two Universities and Dr. Saha had to turn down the invitations.

Another offer came from Sir Gilbert Walker who was then the Director of the Indian Meteorological Department. Sir Gilbert offered Professor Saha all the facilities at the Kodaikanal Observatory to do his work on solar spectra. It was a government post and carried a good salary. But Professor Saha, like a true scientist, did not want to leave the wide path of science for a government post however attractive. Nor did he want to confine his research to solar physics only.



At the Allahabad University, the members of the staff and the Vice-Chancellor felicitating Prof. Saha on his election as a Fellow of the Royal Society, London in 1927. Prof. Saha is seated fifth from the left.



Prof. Eddington at the Science Faculty of the Allahabad University (1937). Prof. Saha is seated fourth from the left and Prof. Eddington is next to him.

# At Allahabad

Finally, Professor Saha decided to leave Calcutta and go to Allahabad University where he thought a better university atmosphere would be available for research.

After being appointed as professor of physics at the Allahabad University in 1923, he came up against the same difficulty that he had experienced in Calcutta. Research funds were not forthcoming from the Government. The library had a few old books, the workshop had no electricity to run the machines, and the laboratory had no apparatus for research. In Calcutta, he had to teach only the M.Sc. Classes, but at Allahabad he had to teach both the B.Sc. and M.Sc. classes. Summer vacation was the only time when he could find time for research, and summer at Allahabad is not a comfortable time for any work. It is much too hot.

His research languished for lack of funds. The Government was not willing to provide additional money. Local men held the University in great esteem, and were of the opinion that Allahabad University was very modern and up-to-date and needed nothing more. The Government found this argument convenient, and refused Dr. Saha's request for research funds.

In 1927, Dr. Saha was elected a Fellow of the Royal

Society (F.R.S.). Sir William Morris, a learned man was then the Governor of Uttar Pradesh (It was then called the United Provinces). He sent a letter of congratulations to Dr. Saha on his being elected a Fellow of the Royal Society. In reply, thanking him for his letter Dr. Saha mentioned how his research work was suffering for the want of funds. Sir Morris immediately granted him Rs. 5,000 per year for carrying on his research work.

This grant enabled Dr. Saha to appoint research scholars to work with him. But money was still needed to buy apparatus and instruments. It is not possible to experiment without apparatus. He could not find any money in the country for this purpose. Finding no other way, he wrote to the Royal Society in London. In 1932, the Royal Society gave him £ 1,500 (then equivalent to about Rs. 20,000) for buying research apparatus and instruments.

Now at last he could start the experiments on his theory of thermal ionozation. He had waited twelve long years for this opportunity. He had been constantly discouraged and frustrated but never once had he forgotten it, nor given up hope. Determination and patience were the strong points in Dr. Saha's character, the qualities that distinguish all true scientists.

His experiments on thermal ionization progressed well, and he established his theory on a strong foundation.

At the same time Dr. Saha opened a new line of research in ionosphere. High up in the atmosphere, the air is electrified or ionized. There are several layers of ionized air, hundreds of miles above the earth. These envelopes of electrified layers of atmosphere constitute the ionosphere.

The ionosphere reflects radio waves and helps reception of radio transmission round the earth. The earth is round. How does a broadcast from the B.B.C. (British Broadcasting Corporation) reach India ? It could come only by bending round a quarter circle of the earth, as the two places are so far apart. But radio waves, like light waves, cannot bend round a circle. They travel straight. The B.B.C. programme comes into our radio receivers only after being reflected from the ionosphere. There are many things to know about the ionosphere, and Dr. Saha started his research on this subject when he was in Allahabad.

## Back to Calcutta

After fifteen years of work in Allahabad, Dr. Meghnad Saha returned to Calcutta University in 1938 as Tarak Nath Palit Professor of Physics. His associates continued the thermal ionization and ionospheric researches at Allahabad.

On joining as Palit Professor in Calcutta, Dr. Saha turned his research in an entirely new direction. He now devoted himself to atomic science or what is known as nuclear physics. The elementary particle 'neutron' had just been discovered, and this explains his interest in nuclear physics. A neutron has no electrical charge. It can therefore hit the nucleus of an atom without being affected by the strong electrical charge of the nucleus. Thus it is easy for a neutron to smash any nucleus for producing new elements. He was convinced that India must catch up with this modern field of science. He started organizing his laboratory for this work, and also the workshop which would build the apparatus for research. But again, as usual, research funds were not forthcoming. In foreign countries, the Government and the industrialists finance scientific research. In our country such consciousness towards science was lacking. Very few realized at that time that science is the foundation of economic and industrial progress of a country.

Dr. Saha built up his cosmic ray research laboratory as the first step leading to atomic research. Cosmic rays come to the earth from all parts of the sky. The rays are invisible, their glow cannot be seen and they are high energy charged particles. Only special instruments can detect them. The strength of cosmic rays does not vary whether it is day or night. The ray can penctrate bricks, concrete or steel plates. Nobody knows definitely where and how they are generated. Since they do not originate from the earth but come from the cosmos (the outer space), they are called 'cosmic rays'.

Before cosmic rays come to the earth's surface, they have to penetrate the atmosphere. They hit the air molecules and ionize the air. The original or primary cosmic ray thus loses its energy, but as a result of hitting the air molecules, it generates shooting electrical particles from the air. These new rays are called the 'secondary cosmic rays'. So a mixture of primary and secondary cosmic rays reach the earth. The higher up one goes into the atmosphere the better is one's prospect of catching more of the primary cosmic rays.

Dr. Saha sent two of his research scholars, Dr. N. Das Gupta and P. C. Bhattacharya to the top of the mountains at Darjeeling to measure the cosmic rays at a height of a little over 2,100 metres (7,000 feet).

For conducting research in nuclear physics, one must have a cyclotron, the atom-smasher. A cyclotion speeds up protons or other charged particles to such a speed and energy that these can strike a material and smash its atoms. The bombardment of the high speed particles produces new

elements in the bombarded material. Sometimes the new material becomes radioactive and can be used for the treatment of diseases. Besides the medical use, the bombarded material reveals the nuclear structure of the atoms, the knowledge of which is very important to scientists.

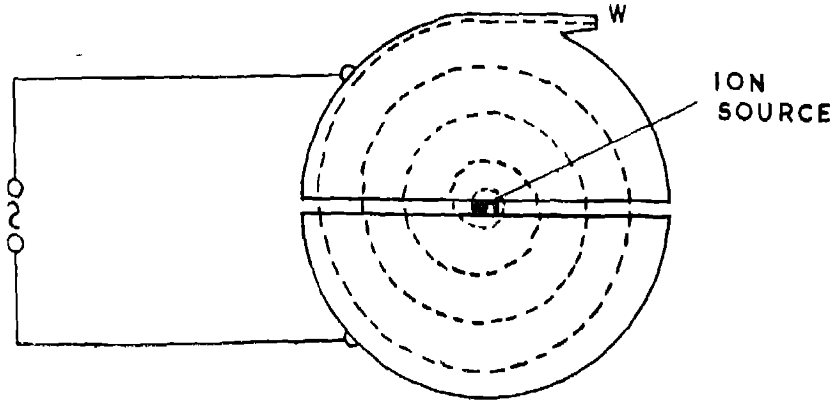



*Fig. 5 The above diagram explains the principle of a cyclotron. Ions starting at the centre move in a curve on account of a magnetic field applied perpendicular to the two D-shaped chambers. An alternating potential is applied to the chambers. Every time they move across the gap between the chambers, they experience a push due to the potential difference. Their kinetic energy goes on increasing and high energy ions come out of the window 'W'.*

Dr. Saha was determined to install a cyclotron, but it required lakhs of rupees. Pandit Jawaharlal Nehru, the Calcutta University, and some business men were sympathetic and helped him in this project. The Tata and Sons made a generous donation of Rs. 60,000.

Dr. Saha entrusted the construction and purchase of the cyclotron parts to his student Dr. B. D. Nag Chaudhuri

who was then working in America with Dr. E. O. Lawrence, the inventor of the cyclotron. Unfortunately, the Second World War started in 1939, and the work of the cyclotron project was hampered. Even the exchange of letters and information became difficult. Dr. Saha became all the more anxious and started writing to his scientist friends in America to obtain information about the latest developments in atomic and nuclear sciences.

Dr. Saha did not know that by then, the Americans had plans to make the atom bomb. The atom bomb project was kept a closely guarded secret. Even the public in America did not know about it. Only a small group of scientists working on the atom bomb project knew about it. They were not even allowed to tell their families what they were doing or where they were working.

Not aware of all this Dr. Saha continued his enquiries about atomic science. An American scientist, a friend of Dr. Saha, cautioned him about the matter.

A delegation of Indian scientists, including Dr. Saha, went to Soviet Union and America in 1944. The war was still on. The American Government arranged a tour programme for the Indian Scientists, but it did not include the atomic bomb projects or the atomic research laboratories. The American security police kept a watch on the Indian scientists, particularly on Dr. Saha.

As the scientists were returning from America, two American security men called on Dr. Saha. In fact, they wanted to find out if Dr. Saha knew about the atom bomb project. After questioning him for sometime they were satisfied that Dr. Saha had not really come to know about

the secrets of the atom bomb ; but being an atomic scientist he was interested in the subject.

In spite of all these difficulties, Dr. Nag Chaudhuri did succeed in bringing the main parts of the cyclotron and started installing it in Calcutta. Several other parts were made locally, The work on high-volt system was undertaken by B.M. Banerjee, and the investigation of radioactivity was done by Dr. Saha's son, Dr. Ajit Kumar Saha, and other young scientists. The vacuum system for the cyclotron was entrusted to me.

Cyclotron produces artificial radioactive elements like radio-calcium and radio-phosphorus. These can be used for medical purposes. Dr. Saha established contacts with the Indian School of Tropical Medicine. They sent their patients to his laboratory.

However, this kind of medical research cannot be carried out successfully and efficiently without a powerful microscope. Diseases like cancer, leukaemia, and tumour bring about changes in the patient's blood. The nature and working of bacteria and viruses have also to be examined under a powerful microscope. Viruses are too small to be seen except by an electron microscope. An electron microscope can magnify objects a hundred thousand times. But it costs about one lakh rupees. At that time there was no electron microscope in India, nor did anyone know how to operate it.

Dr. Saha went around with the begging bowl to get money for an electron microscope. He was lucky : the Central Government and the Government of West Bengal

donated funds, and businessmen like B.C.Law and the Birlas also contributed.

Dr. Saha sent Dr. N. Dasgupta to America in 1945. Professor Marton at the Stanford University is one of the originators of the electron microscope. Dr. Dasgupta designed an electron microscope with Professor Marton's help, and got the major parts made at the Stanford University workshop.

Thus the famous Institute of Nuclear Physics was established in 1950, later it was renamed as Saha Institute of Nuclear Physics, within the campus of the University College of Science at the Calcutta University. Dr. Saha, with his characterstic foresight and indomitable zeal, established two important research departments : one for nuclear physics and the other for biophysics.

# Applied Science

The ultimate aim of science is to benefit mankind. In ancient times, all work was done by hand, by the strength of muscles. There were no machines in those days. Poor men did their work with their own hands. The rich could buy slaves who would toil for them. Bullock carts, camels, horses and elephants were used for carrying loads and for moving from place to place.

Then came the era of science. The steam engine, steamship, telegraph, telephone, motor car and aeroplane were invented. Now they do the work for men, and have emancipated the slaves.

Today, we live in a world which is largely influenced by science. Countries which are advanced in science are prosperous. They are better fed, better clothed, healthier and happier. When science is applied to serve us, it is called applied science.

Applied science is a part of pure science. One cannot jump to applied science without a sound knowledge of pure science. Apparently, however, they look very different. Let us take the example of a camera which helps you in taking a picture. Cameras are produced in a factory. Manufacture of cameras is a big industry in applied

science. But how does the picture form in a camera ? We know that light goes through the lens and forms the image. The interaction of light and lens or glass is the part of pure science about which one should first know. We then try to understand how the picture is fixed on the film. There is a special chemical which fixes it. So we get down to another branch of pure science namely chemistry. When taken separately, the light, the glass or the chemical has nothing to do with photography. The knowledge of pure science brings about, finally, applied science and technology. Research is necessary to pass from one phase to the other.

In our country scientific research is lagging behind that of the other progressive countries, and research in applied sciences lags even more heavily. The industrial progress of the country is slow and so our country is poor.

Dr. Meghnad Saha wanted to industrialize the country and bring about the impact of applied science on our society.

Netaji Subhas was the president of the Indian National Congress in 1938. After Netaji's address, Dr. Saha asked him whether Free India would follow the old traditions of the bullock cart and ploughshare or go in for modern machines and industrialization. If India is to progress, Dr. Saha said, there must be scientific and applied research. He felt scientists must get together and organize scientific education and research, and national planning must be undertaken. Netaji fully supported the view and said that a country could not progress without science, technology and industry.

In 1938, the National Planning Committee was established under the Chairmanship of Jawaharlal Nehru. This Committee had 27 sub-committees to study the various problems facing the country. Dr. Saha was the chairman of the Sub-Committee on Power and Fuel. In 1942, India had just 9 units of electricity per head per year ; while America had 1500 units, England 650 units, and even Mexico (somewhat backward, but a free country) was enjoying 80 units per head. Today about 40 units is the average per head consumption of electricity in India, the average of towns, cities, villages, factories and elsewhere. The cities get more, the villages get very little of electricity.

Electricity is generally produced by machines run by coal. Burning coal turns water into steam, and steam runs turbines and electric generators. India is a land of rivers. When the rivers get flooded every year, the surplus water is very often destructive. Electricity can be generated if the flood waters are stored and made to run generators. This is called hydroelectricity. Many rivers bring down floods, many others are drying up. Rivers can be controlled by scientific methods. Dr. Saha had studied extensively the river problems of India. He was also a member of the Irrigation and Waterways Sub-Committee of the National Planning Committee.

During the next four years after 1938 the National Planning Committee collected much valuable data providing a basis for the future economic planning in India. But in 1942 the 'Quit India' movement was launched against the British. Many national leaders including Nehru, were arrested and jailed by the British Government.

The Second World War had started in 1939. The British were fighting Germany and Italy in Europe, and Japan in Asia. England was making arms and ammunitions for fighting on the European front. The supplies were being shipped to India for fighting Japan. But shipping became difficult and India had no such industry which could produce defence weapons and materials. The British did not develop industries in India. Scientific and industrial research had not been encouraged by them in this country. Now they were in great difficulty.

The Government of India, therefore, established the Council of Scientific and Industrial Research in 1940 to promote the long neglected research in science and industry. Dr. S.S. Bhatnagar became the Director, and Dr. Saha a member of this organization. Dr. Saha thus started to develop instruments and machines.

# River Science

Meghnad was born in the district of Dacca, the land of great rivers. He was a good swimmer, and loved rivers. He knew how useful they are. And, being a scientist, he was a great planner for the scientific control of rivers.

It reminds me of an incident that happened a few years ago. It was a Saturday and Dr. Saha asked some of us to come to his house the next day early in the morning. 'Come by half past six in the morning', he said. We knew that there were some research plans to be discussed. But I thought that half past six on a Sunday morning was too early for work and I would have certainly liked to remain longer in bed on the one holiday in the week.

Nevertheless, we assembled in his house on Southern Avenue at the scheduled time. We were prepared with our papers and expected that Dr. Saha would immediately settle down to work. But instead he said, 'It is a fine morning. I am a member of the Calcutta Life Savers' Society; you can come as my guest. Come let's take a good swim in the lake before we get on to our work.' That was a pleasant surprise indeed. After a vigorous swim we had a hearty breakfast, and then settled down to work.

As far back as in 1913, the Damodar river had a big

flood. This still remains the record flood in the history of the Damodar. Thousands of families were rendered homeless, many died; cattle were washed away and drowned. This was a terrible flood for the district of Burdwan in the Damodar Valley. The national leaders organized flood relief committees and called for volunteers to help. Meghnad Saha was then working for his Master's in Science; he became a volunteer and led his group to the flood affected areas.

Meghnad was greatly moved by the sufferings of the people. Was there no remedy for floods ? Floods had been occuring almost every year. It was Dr. Saha who gave the remedy for the Damodar floods, not in 1913, but thirty years later, in 1943. I shall tell you more about his Damodar Plan a little later.

In 1923, North Bengal was devastated by floods. The British Government did not do much to give relief to the people. Acharya P.C. Ray organized the relief work and Dr. Saha again volunteered his services. He had just then returned from England. Subhas Chandra Bose also joined, and took his relief party to Santahar. Dr. Saha organized the publicity and collection of gifts and donations. He raised twenty three lakhs of rupees for the flood relief fund.

He realized, however, that it was not enough just to organize flood relief after each flood. There should be an organized programme for the prevention of floods. Dr. Saha wrote many articles on floods and their prevention in the *Modern Review* and other papers. He explained the river problems of India; and how rivers were controlled in Germany, America and Russia. These countries study their rivers

scientifically, and they have many laboratories in which river problems are solved. Dr. Saha wanted India to have a number of river research laboratories. Bengal had a special problem. The Ganga, Brahmaputra and Teesta are three large rivers that flow through Bengal. Being a flat country, water flows slowly through the terrain of Bengal and deposits mud and silt as it moves along. Many river channels get silted up, and they meander and sometimes flow along different courses. They leave behind marshy pools where mosquitoes breed and spread malaria. There are many other problems connected with rivers which have to be studied scientifically, if rivers are to be made to give maximum benefit to man and cause the least harm. Dr. Saha continued to write on the need for a river physics laboratory for Bengal, and pursuaded the Government to establish it. The result was that in 1942 the River Research Institute of Bengal was established.

The Damodar had a devastating flood again in 1943. The Damodar Flood Enquiry Committee was set up by the government to find a remedy for the recurring floods in the river. Dr. Saha was a member of that Committee.

Dr. Saha collected the history of the Damodar flood. I was fortunate to have been associated with him in the work. He wrote many articles in *Science and Culture* and other papers to draw the attention of the public and the government for a permanent solution of the floods in the Damodar. He felt that the mighty Damodar could not be tackled by piecemeal remedial measures. All that had been done so far was to build up embankments along the two sides of the river so that during floods, the water would not over-

Prof. Saha with Prof. Darwin, at Calcutta, 1938.

*Left (standing)* : Snehamoy Datta, Satyendra Nath Bose, Debendra Mohan Bose, Nikhil Ranjan Sen, Jnanendra Nath Mukherji, Nagendra Chandra Nag
*Left (sitting)* Meghnad Saha, Jagadish Chandra Bose, Jnan Chandra Ghose

flow the banks. But very often, these embankments could not hold the powerful flow and would give way, causing floods.

Dr. Saha observed that the big floods of the Damodar could not be controlled by embankments. Moreover, we were not really making use of the water but were only allowing it to flood our land and villages, or letting it flow into the Bay of Bengal to no one's benefit.

Dr. Saha presented a plan to the Committee. He felt, in order to control the flood, dams must be built across the Damodar river and its tributaries, particularly the Barakar river. When the flood waters are stopped by the dams in the hilly regions, they would make large reservoirs or lakes, and would not cause floods in the plains. The stored water in the reservoirs could be released slowly throughout the year, and hydroelectricity could also be produced at the same time. Dr. Saha also explained how the Tennessee river in America is controlled by the dams constructed by the Tennessee Valley Authority (T.V.A.).

Dr. Saha prepared the plan for the Damodar Valley based on the pattern of the T.V.A. His idea was accepted, and the Damodar Valley Corporation (D.V.C.), a multipurpose project was started. Dams are built to hold the monsoon waters which cause floods, to use the stored water for generating hydroelectric power, and to supply water for irrigation.

## *Establishing Scientific Societies*

Dr. Saha with his usual insight soon realized that the work of individual scientists could not benefit the entire country unless they got together and exchanged their ideas. The development of science is comparatively recent in this country having started only forty or fifty years ago. In Europe science and scientific research started in a serious way about three centuries ago. It was imperative for India's scientific progress that our scientitists get together and get to know each other's research work, and also keep in touch with scientific research that is being carried on in other countries.

The Indian Science Congress Association was established in 1913, as the first forum of Indian scientists, where they could discuss the scientific work being done in the country and abroad. Dr. Saha became the President of the Section on Physics and Mathematics for the 1925 Session of the Science Congress.

Dr. Saha wanted more opportunities for the scientists to meet together. He established an Academy of Science in Uttar Pradesh which, in 1934, was renamed the National Academy of Sciences, India. This was, however, in the nature of a local scientific society in the State of Uttar Pradesh.

Dr. Saha brought up a proposal before the Science Congress of 1934 that a scientific society of an all-India character should be established. As a result the National Institute of Sciences was established in 1935. Dr. Saha was its Vice-President in the beginning, and later became its President from 1937 to 1939.

Dr. Meghnad Saha established many new scientific organizations and inspired new scientific thought. When he finally came back to Calcutta in 1938, he not only started new research lines at the University but set himself to reorganize and revitalize the Mahendra Lal Sircar Laboratory known as the Indian Association for the Cultivation of Science. This is also popularly known as the Science Association. This was housed in Dr. Mahendra Lal Sircar's residential building at 210, Bow Bazar Street. At one time Dr. C.V. Raman was its President. Dr. Saha was its Secretary in 1944 and became its President in 1946.

When Dr. Saha became the President of the Science Association, his first concern was to find a better and bigger place for this research organization. The building on Bow Bazar Street was very old and did not have enough space for research work. He persuaded the Bengal Government and the Central Government to grant funds for the Association. A grant of Rs. 3,50,000 per year was the result of his endeavours. Thirty *bighas* (approximately 10 acres) of land was acquired at Jadavpur on the outskirts of Calcutta, and the Science Association shifted to the new building in 1951. But Dr. Saha relinquished his position as the President of the Association in 1950, since he himself had made it a rule that no President of the Indian Association for

the Cultivation of Science should hold the position for more than three years. Dr. J.C. Ghose became the next President of the Association.

In 1953, the Government of India appointed Dr. Saha as the Director of the Science Association, a position which he held till his death.

The Science Association started with new vigour. Research activities expanded, and it needed more funds. Dr. Saha submitted a five year plan for the Association : for engaging more research scientists, buying new apparatus, and for the expansion of its workshop and library. The Government of India in order to encourage scientific and research developments, made a grant of about Rs. 50 lakhs to the Association for the five year plan.

In spite of his absorbing interest in establishing new research institutes and reorganizing the old ones, Dr. Saha did not forget the common man and his need for scientific knowledge. He felt very strongly that unless the common man appreciated science, a handful of scientists could not bring the impact of science on industry or society. The public had to be made science conscious, if a scientific atmosphere was to be created in the country at every level of society. Only then would science and industry make any appreciable progress in the country. Scientific thought must be disseminated to the layman.

In order to achieve this, Dr. Saha established the Indian Science News Association in 1935, and started a popular scientific journal called *Sceince and Culture.* The purpose of this magazine was to present scientific achievements in simple and lucid terms, so as to enable the common

man to know about scientific developments. Dr. Saha himself wrote more than a hundred articles in 'Science and Culture.' The range of subjects on which he wrote is astounding. They covered National Planning, science education, industry, geophysics, flood and famine control, atomic physics, steel industry, calendar reform, archaeology and several other subjects. His writings indicate his profound knowledge and understanding of the subjects.

The Carnegie Trust of America invited Dr. Saha in 1936 to visit various scientific institutions in Europe and America. He did not want to travel by a boat or an aeroplane. He took the land route as far as possible. Taking his 13 year old son Ajit with him, he took a ship to Basra. From Basra he boarded a train to go to Baghdad, but on his way he stopped at the old city of Ur in Mesopotamia, which the British Archaeologist, Sir Leonard Wooley, had excavated. Ur is a 4000-year old city in the Tigris-Euphrates Valley, and a notable example of ancient culture in Asia. Dr. Saha was extremely interested in ancient history and culture, and so made a trip to Ur. In India he had visited Mohenjo-daro, Harappa, Pataliputra, Buddha Gaya, Rajgir and other places of archaeological importance. From Baghdad Dr. Saha and his son Ajit took the motor route through the desert lands. They went up to Beirut, and then to Heifa, from where they embarked on a ship and sailed through the Mediterranean Sea.

Dr. Saha's interest in ancient history and civilization stemmed from his deep interest in science. This sounds queer. How could modern science, technology and industry in which Dr. Saha was fully engaged have any connection

with ancient history and culture ? A deeper consideration would show that they are all inter-related, especially if one is to have a thorough understanding of the subjects. Science in ancient times was closely associated with religion and culture and also with astronomy and medicine. As human civilization developed, science and social history changed side by side. With the mechanization of industry and advancement in scientific knowledge, the entire history of man took a very definite turn. History does not mean only the stories of kings and winning or losing of battles. Real history is the story of man: his intellectual and social progress in which science plays an immensely important part. Dr. Saha's versatile mind grasped this truth intuitively even at an early age. This created in him a genuine interest in archaeology and ancient civilizations of mankind. He once remarked that very few people knew that his first original publication was a paper on some archaeological findings of Buddhistic influences in East Bengal. He also had a deep interest in Indian astronomy; and on one occassion he was invited to deliver a lecture in the Maharaja's College, Jaipur in Rajasthan. He took this opportunity to visit the famous Jantar Mantar, the great Hindu system of astronomical observatory. This was erected about the year 1724 by Maharaja Sawai Jai Singh II, the astronomer ruler of Ambar. The Pundit, himself a learned man, was overwhelmed by Dr. Saha's profound knowledge of Hindu astronomy and expressed his admiration.

Dr. Saha's love for mathematics and astronomy led him to study the different religions of the world. Astronomy is the oldest science in any country, and the influence

of religion is evident in the ancient astronomy of all countries. Some 4000 to 6000 years ago, astronomical science had its beginning in Egypt, India, China, Greece, Rome and Arabia. Even as far back as 4236 B.C., the Egyptians had the 30-day month and 12-month a year system. This is the oldest calendar. But they soon discovered that 12 months of 30 days each did not bring the sun to the same position in the sky after 360 ($12 \times 30$) days of their year. They noticed that it took about 5 more days for the sun to come back to the same position in the background of the stars. Thus came the 365-day year.

Much later, a discrepancy of one-fourth of a day was discovered and each year came to be taken as $365\frac{1}{4}$ days. This is why every fourth year, one day is added to the month of February to make it a 29-day month to compensate for the loss of one fourth of a day in each of the previous three years. This is called the leap year. Even this is not a perfectly accurate calculation.

Dr. Saha studied the ancient and modern calendar systems of various countries. He wanted to evolve an easy and accurate calendar. He devoted himself to these studies for twenty years. The Council of Scientific and Industrial Research formed the Calendar Reform Committee in 1952 and Dr. Saha was appointed its Chairman. He submitted the report in 1955.

This report shows his profound knowledge of astronomy and mathematics as well as the history of civilization. The UNESCO was also engaged in framing a Universal Calendar. Dr. Saha's report on Calendar Reform has been highly appreciated by the UNESCO.

# 13

## *National Service and Politics*

For forty years of his life, Dr. Saha was steeped in science—studying, teaching and doing research. His patriotic feelings were rarely given open expression, although he had joined in school strikes during the partition of Bengal and had intimate contacts with the great nationalists and political leaders of the day. He never took an active part in politics.

However, he realized that it was difficult to bring about expansion of scientific research or education under a foreign rule. Everything, research or education, flood or refugee problem, industry or national planning, depended on the Government. And the Government, he found, was too slow and unappreciative to act with urgency.

Since 1930, Dr. Saha was connected with several committees of the Government, usually in an honorary and advisory capacity. He was mostly concerned with science, education and planning. When India became free from the British rule in 1947, our National Government took up development and planning very earnestly. But the old ideas and defects found their way into the new system also. Dr. Saha felt that the defects must be removed if work was to go on at a faster rate, and technology and industry were to receive the necessary attention.

Dr. Saha discussed these ideas with Sarat Chandra Bose. Sarat Bose advised him to enter the parliament where he felt Dr. Saha's ideas and advice would be effective. He told Dr. Saha, 'You cannot do much from outside the Government.' Dr. Saha was not inclined to enter politics, but Bose and other friends were emphatic that his profound knowledge and understanding of science, education and industrial planning would be of great value to the National Government. He was elected a Member of Parliament in 1951.

Dr. Saha did not stand for the election as a candidate of the Congress Party. He was opposed to the traditional idea of Charkha and Khadi. He believed in large mechanized industries, and rapid progress through science and technology. He was elected as an independent member in the Lok Sabha (Lower House of the Indian Parliament).

Although an opposition member, Dr. Saha's views and criticisms in the parliament were greatly respected. But his critical observations on the defects in planning and administration often embarrassed the ruling party. Once a Congress leader told him jokingly that as a scientist, Dr. Saha should confine himself to science. To that Dr. Saha said, 'Scientists are blamed for living in an ivory tower. I also remained in it. But time has changed. Today science is intimately connected with national planning and administration. This is why I have gradually shifted to the field of politics to serve my country with my scientific knowledge and understanding.'

Dr. Saha's service to the country is unparalleled : his untiring efforts in building educational and research

institutions, in inspiring men of science, and, in guiding national planning. His services were not confined to education and research alone; he was personally interested in the common man. In his youth he worked as a flood relief volunteer. In his advanced age, inspite of the celebrity he had become, he did not forget the suffering men and women.

In 1950, Dr. Saha set up a large relief organization for the displaced persons from East Bengal. He was not in too good a state of health at this time. He developed high blood pressure and sustained a partial paralysis on the left side of his face. In spite of his indifferent health, he did not stop working hard. He went round the refugee camps in various places including those in Assam and Tripura. He continuously drew the attention of the Govenment to the misery of the displaced persons.

On February 13, 1956, Dr. Saha started for Delhi to attend the Budget Session of the Parliament. Many things were to be discussed : the refugee problem, unemployment and retrenchment problems, river control, etc.

On February 16th, he was walking up the slope near the Parliament House, with some important papers in his hand. Suddenly he felt giddy, and fell down. As the crowd gathered, a gentleman recognized Dr. Saha and came forward to help. He was rushed to the hospital, but by then all was over.

The sad news spread all over the world. India and the world lost a great scientist and humanist.

Is it correct to say that only the rich men's sons living in big cities can become great ? Meghnad was a son of very

poor parents, and a boy from a small village away from cities and towns. Yet, he became so great, so renowned a scientist. He was highly respected, both at home and abroad. Meghnad Saha became great in spite of his poverty and other difficulties. One can become great only through one's own efforts.

Meghnad Saha not only became great himself but imparted a touch of greatness to all those whom he associated with—his students, hundreds of them and even his children. Above all he worked all his life to make our country great.

# A Glossary of Technical Terms

## Atom

Smallest particle of an element that can exist. A combination of atoms is known as a molecule. An atom is made up of a central core called the nucleus consisting of protons and neutrons, with electrons revolving in their orbits round the nucleus. An electron and a proton bear a negative and a positive charge of electricity respectively, whereas the neutron is electrically neutral. Electron, proton and neutron are elementary particles which constitute atoms. Electron and proton have an equal amount of electrical charge, but of opposite kind. A normal atom, as a whole, is electrically uncharged or neutral, for it contains equal number of protons (in the nucleus) and electrons in the outer orbits. An atom is like a miniature solar system, with a heavy nucleus at the centre and lighter electrons orbiting around it.

## Cosmic Rays

High energy radiations originating from sources outside the earth. These primary cosmic rays also kick up secondary cosmic rays when they enter the earth's atmosphere and hit the particles present in it. Cosmic rays consist of high energy elementary particles and gamma rays.

## Einstein's Theory of Relativity

Albert Einstein propounded his 'Special Theory' of Relativity in 1905, and the 'General Theory' in 1915. Some of the ideas contained in these are as follows . (1) All motions are relative, there is nothing that can be called absolute motion. We cannot perceive the motion of the earth without looking at the sun or the stars. If two cars are running in the same direction with equal speed, (say 30 miles per hour), the passenger of one car will find the other car stationary. A person standing on the road will find the cars moving at 30 miles per hour, but passengers in a car going in the opposite direction at 40 m.p.h. will find the other cars

speeding away at 70 m.p.h. No one is wrong. (2) While the speed of a car or of any moving body can be altered by moving with or against it, the speed of light (300,000 Km per second or 186,000 miles per second) cannot be altered by the observer's motion. The velocity of light is constant under any condition of motion. This is a queer fact that leads to various conclusions in the theory of relativity. (3) The theory proves that a moving body shortens its size (length) in the direction of motion ; higher the speed, the greater the contraction, until it vanishes when it attains the speed of light. Further, (4) with the increase of speed, a body increases its mass, and (5) matter and energy are interchangeable : matter can be converted into energy (as in an atom bomb), and energy (like light waves) can behave like material particles. This is how Einstein predicted bending of light by gravitational attraction which was proved by the observation of 'Star Shift'. (See Figure 1).

**Element**

A substance containing only one kind of matter. Textbooks on physics and chemistry will tell you that there are 92 natural elements. Some elements are gaseous (like hydrogen, oxygen, nitrogen, etc.), some are liquid (like bromine, mercury), others are solid (like sulphur, iodine, copper, tin, etc.), under ordinary temperatures and pressures. Water is not an element, it is a compound of hydrogen and oxygen elements. Common salt is also a chemical compound of sodium and chlorine. Brass is an alloy of copper and zinc. Steel is also an alloy of iron, carbon and some other metals.

**Gravity**

Any substance when not supported falls to the ground. The force of the earth responsible for this fall is called gravity. All material bodies have this property of gravitational attraction. It is because of the gravity of the sun that the earth and the other planets cannot run away.

**Ion**

Atom or a group of atoms, which has had one or more electrons added to it or taken away from it. An ion is, therefore, electrically charged. A normal atom is electrically neutral or uncharged.

**Nebula**

Faint, shining cloud of matter seen outside our star system. These are giant masses of gas, but also contain millions of stars. Each nebula is a star system, often called star island.

**Radioactivity**

Spontaneous breakdown of the nuclei of certain elements known as radioactive elements. Such a phenomenon occurs also in the case of the artificially created atoms and is known as 'artificial radioactivity' as differentiated from the similar phenomena occuring in case of the natural elements and is known as 'natural radioactivity'. Radioactive elements are radium, uranium, thorium, and a few others. They emit alpha, beta and gamma rays. The alpha ray is a shooting particle of helium nucleus. The beta ray is nothing but a shooting electron. The gamma ray is like a very short wave X-ray radiation.

**Radio Transmission**

The technique used for sending signals over great distances without the use of wires. Radio waves are electromagnetic waves like light waves. But radio waves are much longer than light waves.

**Saha's Ionization Theory**

It was pointed out by Dr. Meghnad Saha that if you want to recognize an element in the sun or a star by its spectral colour, you must first know in what state of thermal ionization the element exists there. He could tell us by calculation the degree of ionization prevailing at various temperatures and pressures in different stars, and accordingly, the kind of spectral light one could expect. Striking results followed—some observed spectral lines, not understood before, were identified as due to some common element in an uncommon state of ionization, some missing spectral lines were explained and new predictions were made and found correct. The theory was first published in 1920. Saha's idea brought in new thinking in astrophysics. It helped scientists to understand the colour and composition of stars, a field where no scientific explanation existed before.

**Spectroscopy**

It is the method of analysing light to find out the composition of substances. Spectrum is the coloured band or lines which are separated from the mixed light when it passes through a prism. The light from a burning or glowing substance has its own colour-composition. The colour-composition can be studied through a spectroscope. The spectrum thus gives a clue to the substance which is emitting the light.

**Sun-spots**

Dark spots on the surface of the sun. These are the patterns resulting from the uneven temperatures of the solar matter near the surface of the sun.